AI Planning
Exercise Sheet 5

Date: 27.11.2014
Students: Axel Perschmann, Tarek Saier

Exercise 5.1

As given in the lecture slides:

Proof by induction over the structure of χ.
Base case $\chi = \top$: then $s' \models \top$.
Base case $\chi = \bot$: then $s \not\models \bot$.

Base case $\chi = a \in A$: assume $s \models a$ and $on(s) \subseteq on(s')$.
Wich $a \in on(s)$ we get $a \in on(s')$, hence $s' \models a$.

Inductive case $\chi = \chi_1 \wedge \chi_2$

$$\begin{aligned} s \models \chi &\iff s \models \chi_1 \wedge \chi_2 \\ &\iff s \models \chi_1 \text{ and } s \models \chi_2 \\ &\implies s' \models \chi_1 \text{ and } s' \models \chi_2 \\ &\iff s' \models \chi_1 \text{ and } \chi_2 \\ &\iff s' \models \chi \end{aligned}$$

Inductive case $\chi = \chi_1 \vee \chi_2$ (Analogous to previous case)

$$\begin{aligned} s \models \chi &\iff s \models \chi_1 \vee \chi_2 \\ &\iff s \models \chi_1 \text{ or } s \models \chi_2 \\ &\implies s' \models \chi_1 \text{ or } s' \models \chi_2 \\ &\iff s' \models \chi_1 \text{ or } \chi_2 \\ &\iff s' \models \chi \end{aligned}$$

Exercise 5.2

(a) $\Pi^+ = \langle A, I, O, \gamma \rangle$ with A, I, γ unchanged and

$$\begin{aligned} O &= \{eatCake^+, bakeCake^+\} \\ eatCake^+ &= \langle haveCake, \top \wedge haveNoCake \wedge eatenCake \rangle \\ bakeCake^+ &= \langle haveNoCake, haveCake \wedge \top \rangle \end{aligned}$$

(b) $\pi = bakeCake, eatCake$
π in Π results in $\{haveCake \mapsto 0, eatenCake \mapsto 1, haveNoCake \mapsto 1\}$
π^+ in Π^+ results in $\{haveCake \mapsto 1, eatenCake \mapsto 1, haveNoCake \mapsto 1\}$

Exercise 5.3

Considerations:
$h^{Manhattan}(s)$ sums up distances of tiles to their target position.
$h^{+}(s)$ considers the relaxed planning task with relaxed operators. This means when a tile is moved it moves to the new position but also "stays" at the old ($at()$ for the old position is not negated). χ of each o^{+} should be the same in Π and Π^{+} though.

(a)
$h^{Manhattan}(s)$ is equal to $h^{+}(s)$ without the restictions given by χ for each o^{+}. In other words: for $h^{Manhattan}(s)$ you can move any tile freely, for $h^{+}(s)$ you can move tiles freely along the paths where $empty(p_{i,j})$ was made true at one point or was true for s in the first place. Therefore $h^{Manhattan}(s)$ can never yield a larger number than $h^{+}(s)$.

(b)

$$s = \begin{matrix} t_0 & t_1 & t_2 & t_3 \\ t_4 & t_5 & t_6 & t_7 \\ t_8 & t_9 & t_{10} & t_{11} \\ t_{14} & t_{13} & t_{12} & - \end{matrix}$$

$h^{Manhattan}(s) = (|0-2| + |3-3|) + (|2-0| + |3-3|) = 4$
$h^{+}(s) = 7$ with plan:
$move(t_{12}, p_{2,3}, p_{3,3})$
$move(t_{13}, p_{1,3}, p_{2,3})$
$move(t_{14}, p_{0,3}, p_{1,3})$
$move(t_{14}, p_{1,3}, p_{2,3})$
$move(t_{12}, p_{3,3}, p_{2,3})$
$move(t_{12}, p_{2,3}, p_{1,3})$
$move(t_{12}, p_{1,3}, p_{0,3})$